WHAT IS CLAIMED IS:

1. A method of manufacturing a semiconductor device in which a semiconductor wafer, on the first face of which a plurality of semiconductor elements are formed, is divided into individual pieces of semiconductor elements so as to obtain a semiconductor device, the thickness of which is not more than 100 μm, the method comprising:

a sheet attaching step of attaching a protective sheet, capable of being peeled off, to the first face;

a thickness reducing step of reducing the thickness of the semiconductor wafer to not more than 100 μm by shaving a second face, which is opposed to the first face, by means of machining;

a mask forming step of forming a mask for determining cutting lines to divide the semiconductor wafer into the individual pieces on the second face;

a plasma dicing step of dividing the semiconductor wafer to the individual pieces by carrying out plasma-etching on the cutting lines when the semiconductor wafer is exposed to plasma from the mask side;

a mask removing step of removing the mask by utilizing plasma;

a micro-crack removing step of removing micro-cracks, which are generated on the second face in the thickness

reducing step, by carrying out plasma-etching on the second face from which the mask has been removed; and

a sheet peeling step of peeling the protective sheet from each semiconductor device which has been obtained as an individual piece.

2. A method of manufacturing a semiconductor device according to claim 1, wherein the plasma dicing step, the mask removing step and the micro-crack removing step are carried out by the same plasma processing apparatus.

3. A method of manufacturing a semiconductor device according to claim 1; wherein an adhesive sheet is attached to the second face after the completion of the micro-crack removing step and then the protective sheet is peeled off.

4. A method of manufacturing a semiconductor device according to claim 1 or 2, wherein mixed gas containing at least fluorine gas is used as plasma generating gas to be used in the plasma dicing step.

5. A method of manufacturing a semiconductor device according to claim 1 or 2, wherein gas containing oxygen is used as plasma generating gas to be used in the mask removing step.

6. A method of manufacturing a semiconductor device according to claim 1 or 2, wherein the same type gas as the plasma generating gas used in the plasma dicing step is used as the plasma generating gas to be used in the micro-crack removing step.

7. A method of manufacturing a semiconductor device according to claim 1 or 2, wherein mixed gas containing at least fluorine gas is used as the plasma generating gas to be used in the micro-crack removing step.

8. A method of manufacturing a semiconductor device according to claim 7, wherein the same type gas as the plasma generating gas used in the plasma dicing step is used as the plasma generating gas to be used in the micro-crack removing step.

9. A plasma processing apparatus of executing plasma dicing, removing a mask and removing micro-cracks by carrying out plasma processing on a semiconductor wafer in which a protective sheet is attached on the first face on which semiconductor elements are formed and a mask for determining cutting lines to divide the semiconductor wafer into individual pieces of the semiconductor elements is

formed on the second face opposite to the first face, the plasma processing apparatus comprising:

a processing chamber;

a first electrode having a plane with which the protective sheet tightly comes into contact in the processing chamber;

a second electrode opposed to the first electrode in the processing chamber;

a holding means for holding the semiconductor wafer by the first electrode under the condition that the protective sheet tightly comes into contact with the plane;

a pressure reducing means for reducing pressure to a predetermined value in the processing chamber;

a plasma generating gas supplying means for selectively supplying a plurality of types of plasma generating gases into the processing chamber;

a pressure controlling means for controlling pressure in the processing chamber when plasma generating gas is supplied;

a high frequency electric power supply section for supplying a high frequency voltage upon the first electrode so as to transfer the plasma generating gas, which has been supplied into the processing chamber, into a plasma state; and

an electrode distance changing means for changing a distance between the first and the second electrode.

10. A plasma processing apparatus according to claim 9, wherein the electrode distance changing means makes an electrode distance between the first and the second electrode in the case of removing the mask be larger than an electrode distance in the cases of plasma dicing and removing micro-cracks.

11. A plasma processing apparatus according to claim 9, wherein the holding means includes a vacuum attracting means for attracting the protective sheet by vacuum via a plurality of suction holes which are open to the plane.

12. A plasma processing apparatus according to claim 9, wherein the protective sheet includes an insulating layer, the plane is made of a conductive material which is the same as the material of the first electrode, and

the holding means includes a DC voltage supplying means for electrostatically attracting the semiconductor wafer by utilizing the Coulomb's force acting between the semiconductor wafer and the plane, which are separate from each other by the protective sheet, when DC voltage is supplied upon the electrode.

13. A plasma processing apparatus according to claim 9, wherein the plasma generating gas supplying means supplies mixed gas containing fluorine gas into the processing chamber in the steps of the plasma dicing and the micro-crack removing.

14. A plasma processing apparatus according to claim 9, wherein the plasma generating gas supplying means supplies the same mixed gas containing fluorine gas into the processing chamber in the steps of the plasma dicing and the micro-crack removing.

15. A plasma processing apparatus according to claim 9, wherein the plasma generating gas supplying means supplies gas containing at least oxygen into the processing chamber in the step of the mask removing.

16. A plasma processing apparatus according to claim 9, further comprising a cooling means for cooling the first electrode.

17. A plasma processing method in which the steps of plasma dicing, removing a mask and removing micro-cracks are executed by carrying out plasma processing on a

semiconductor wafer, on the first face having semiconductor elements of which a protective sheet is attached, on the second face on the opposite side to the first face of which a mask to determine cutting lines for dividing the semiconductor wafer into individual pieces of the semiconductor elements is formed, the plasma processing method comprising:

a wafer holding step in which the semiconductor wafer is held by a first electrode under the condition that the protective sheet is tightly contacted with a plane of the first electrode in a processing chamber;

a first condition setting step in which an electrode distance between a first electrode and a second electrode, which is arranged being opposed to the first electrode, and pressure in the processing chamber are set at a first condition;

a plasma dicing step in which portions of the cutting lines are plasma-etched when a first plasma generating gas is supplied into the processing chamber and a high frequency voltage is supplied between the first electrode and the second electrode so that the first plasma generating gas is transferred into a plasma state;

a second condition setting step in which the distance between the electrodes and the pressure in the processing chamber are set at a second condition;

a mask removing step in which the mask is removed by ashing when a second plasma generating gas is supplied into the processing chamber and a high frequency voltage is supplied between the first electrode and the second electrode so that the second plasma generating gas is transferred into a plasma state;

a third condition setting step in which the distance between the electrodes and the pressure in the processing chamber are set at a third condition; and

a micro-crack removing step in which micro-cracks remaining on the second face, from which the mask has been removed, are removed by plasma etching when a third plasma generating gas is supplied into the processing chamber and a high frequency voltage is supplied between the first electrode and the second electrode so that the third plasma generating gas is transferred into a plasma state.

18. A plasma processing method according to claim 17, wherein the first plasma generating gas is a mixed gas containing fluorine gas.

19. A plasma processing method according to claim 17, wherein the second plasma generating gas contains oxygen.

20. A plasma processing method according to claim 17, wherein the third plasma generating gas is a mixed gas containing fluorine gas.

21. A plasma processing method according to claim 17, wherein the first plasma generating gas and the third plasma generating gas are the same type mixed gas.

22. A plasma processing method according to claim 17, wherein the pressure in the processing chamber in the first condition is set in the range from 5 to 300 [Pa] and the electrode distance is set in the range from 5 to 50 [mm].

23. A plasma processing method according to claim 17, wherein the pressure in the processing chamber in the second condition is set in the range from 5 to 100 [Pa] and the electrode distance is set in the range from 50 to 100 [mm].

24. A plasma processing method according to claim 17, wherein the pressure in the processing chamber in the third condition is set in the range from 300 to 2000 [Pa] and the electrode distance is set in the range from 5 to 20 [mm].

25. A plasma processing method according to claim 22, wherein the electric power of the high frequency electric power supply in the plasma dicing step is 500 to 3000 [W].

26. A plasma processing method according to claim 23, wherein the electric power of the high frequency electric power supply in the mask removing step is 100 to 1000 [W].

27. A plasma processing method according to claim 24, wherein the electric power of the high frequency electric power supply in the micro-crack removing step is 50 to 3000 [W].